

Remarks/Arguments

In response to the final Office Action mailed 21 March 2007, Applicant filed an Amendment on 21 May 2007 in response to which the Examiner issued an Advisory Action refusing to enter the Amendment. Applicant respectfully requests that the Amendment filed on 21 May 2007 *not be entered*.

Applicant respectfully requests favorable reconsideration of the subject application, particularly in view of the above amendment and the following remarks. Applicant respectfully urges that there is no additional fee for this amendment as the number of independent claims is less than three (3) and the total number of claims in the application remain unchanged. Claims 1-14 are currently pending in the subject application.

Applicant has amended the paragraph beginning at Page 5, line 20 of the specification to provide that the anode catalyst layer of the invention claimed by Applicant comprises a binder material comprising lignin. Applicant respectfully urges that support for this amendment may be found in previously presented (and entered) Claim 1 and at Page 11, lines 10-12, where it is indicated that the proton conductive material is selected from the group consisting of, among other things, ligno-sulfonic acid and at Page 12, lines 1-4, where it is indicated that, in accordance with one embodiment of this invention, the electron conductive material comprises a grafted

polymer comprising polyaniline grafted to lignin. Accordingly, Applicant respectfully urges that this amendment incorporates no new subject matter into the application.

Applicant has added a new independent claim, Claim 40, which requires that the claimed fuel cell is a direct methanol fuel cell. This amendment is fully supported, for example, at Page 2, lines 10-13 of the specification where it is stated that “the invention relates to direct methanol fuel cells...” Accordingly, Applicant respectfully urges that this amendment is fully supported by the application as originally filed and, thus, incorporates no impermissible new subject matter into the application.

Claim 1 has been objected to on the basis of informalities cited by the Examiner. In particular, the Examiner has required that Applicant change “and” to “or” in the second to last line of Claim 1. Applicant respectfully traverses this requirement on the basis that the proposed language would unduly narrow the scope of the claim to the proton conductive material or the electron conductive material comprising lignin and excluding the embodiment in which both the proton conductive material and the electron conductive material comprise lignin. See *Brown v. Air Products and Chemicals, Inc.*, 229 F.3d 1120, 56 U.S.P.Q.2d (BNA) 1456 (Fed. Cir. 2001) in which it was found that the language “at least one of two-digit, three-digit, or four-digit representations” in a recitation relating to the setting of year data in a

computer clock excluded an apparatus able to perform all three alternatives. The language employed by Applicant is intended to include an anode catalyst layer comprising a proton conductive layer comprising lignin, an anode catalyst layer comprising an electron conductive layer comprising lignin, and an anode catalyst layer comprising a proton conductive layer comprising lignin *and* an electron conductive layer comprising lignin. Changing the language of Claim 1 as required by the Examiner would exclude the third embodiment from the scope of the claimed invention, which is contrary to the intent of Applicant, and which embodiment is fully supported by the description and remaining claims of the application as originally filed. Accordingly, Applicant respectfully urges that the existing language correctly represents the scope of the invention as intended by Applicant; and, thus, Applicant respectfully requests withdrawal of the objection to Claim 1.

Claim 1 has been rejected under 35 U.S.C. 112, first paragraph, because the specification is alleged by the Examiner not to be reasonably enabling for “proton conductive material and said electron conductive material comprising lignin”. More particularly, the Examiner has indicated that although the specification teaches a proton conductive material and/or an electron conductive material comprising a ligno-sulfonic acid and/or an electron conductive polyaniline grafted to lignin, there is no generic teaching that the lignin can be for any proton conductive material or any

electron conductive material. In response to this rejection, Applicant has amended the specification, consistent with the language of Claim 1, to include a generic teaching that the proton conductive material and/or the electron conductive material of the anode catalyst layer of the invention claimed by Applicant may comprise lignin. Accordingly, Applicant respectfully urges that this amendment overcomes this rejection.

Claims 1-14 have been rejected under 35 U.S.C. 112, second paragraph as failing to define the invention in the required manner. Specifically, the Examiner indicates that the claim(s) are narrative in form and replete with indefinite and functional or operational language. The Examiner further indicates that the structure which goes to make up the device must be clearly and positively specified; the structure must be organized and correlated in such a manner as to present a complete operative device; and the claim(s) must be in one sentence form only. Applicant respectfully traverses this rejection. Applicant notes that *no example of indefinite and functional or operational language has been cited by the Examiner; no example of missing structure has been cited by the Examiner; and no claim which is not in one sentence form has been cited by the Examiner*. Applicant has carefully reviewed the rejected claims for examples of the problems stated by the Examiner, but has been

unable to find any such examples. Accordingly, Applicant respectfully requests that this rejection be withdrawn.

The invention claimed by Applicant is a fuel cell comprising an anode electrode, a cathode electrode and a proton exchange membrane electrolyte disposed there between. An anode catalyst layer is disposed on the electrolyte facing surface of the anode electrode or the anode electrode facing surface of the electrolyte. The said anode catalyst layer comprises a proton conductive material and an electron conductive material substantially uniformly dispersed throughout the catalyst layer. The proton conductive material and/or the electron conductive material comprise lignin. In accordance with one embodiment of this invention, the lignin may be in the form of ligno-sulfonic acid. In accordance with an alternative embodiment of this invention, the lignin is part of a grafted polymer, e.g. polyaniline grafted to lignin. Applicant respectfully urges that the prior art relied upon by the Examiner for rejection of the subject application neither teaches nor suggests a fuel cell comprising an anode electrode having an anode catalyst layer comprising a proton conductive material and an electron conductive material substantially uniformly dispersed throughout the catalyst layer where the proton conductive material and/or the electron conductive material comprises lignin as claimed by Applicant.

Claims 1-14 have been rejected under 35 U.S.C. 103(a) as being unpatentable over Srinivas, U.S. Patent Publication No. 2004/0110051 A1 (hereinafter "the Srinivas publication") in view of Tripathy et al., U.S. Patent Publication No. 2002/0183470 (hereinafter "the Tripathy et al. publication"). This rejection is respectfully traversed. The Srinivas publication teaches a composition comprising particulate carbonaceous material and a sulfonated conducting polymer containing hetero atoms. Devices comprising the composition, which may include a metal, include supported electrocatalysts, membrane electrode assemblies and fuel cells. However, the Srinivas publication neither teaches nor suggests an anode catalyst comprising lignin as claimed by Applicant, a fact acknowledged by the Examiner. Rather, the Examiner relies upon the Tripathy et al. publication as teaching an anode catalyst comprising lignin as claimed by Applicant.

The Tripathy et al. patent teaches a method for polymerization of aromatic monomers using derivatives of hematin including assembled hematin. In one embodiment, the polymerization is carried out in the presence of a template, along which aromatic monomers align. Assembled hematin includes alternating layers of hematin and a polyelectrolyte, which are deposited on an electrically charged substrate (Abstract). The Tripathy et al. publication also teaches the use of electrically conductive polymers in a variety of electronic devices including electro-chromic

devices, light-emitting diodes, electrostatic discharge protection, and light weight batteries (Paragraph [0003]). *Nowhere does the Tripathy et al. publication teach the use of electrically conductive polymers in fuel cells.* In addition, the Tripathy et al. publication also teaches a method for producing lignosulfonate-Pani complex using hematin (Paragraph [0069]). *Nowhere does the Tripathy et al. publication teach or suggest the use of a lignosulfonate-Pani complex as part of an anode catalyst layer which is both proton and electron conductive employed in a fuel cell as claimed by Applicant.* Applicant further respectfully urges that the Tripathy et al. publication does not teach or suggest the use of a lignosulfonate-Pani complex as a component of a proton conductive material in accordance with certain embodiments of the invention claimed by Applicant. Thus, Applicant respectfully urges that it is mere conjecture on the part of the Examiner as to the suitability of a lignosulfonate-Pani complex for use in the anode catalyst layer of a fuel cell as claimed by Applicant.

The Examiner argues:

“It is well known in the art that a PEM fuel cell and battery are electrochemical devices with anodes, cathodes and a proton exchange membrane electrolyte. The PEM fuel cell and battery are therefore functional equivalence (sic). The substitution of known equivalent structures involves ordinary skill in the art.”

That is, according to the Examiner, because batteries and PEM fuel cells are both electrochemical devices having anodes, cathodes and proton exchange membrane electrolytes, batteries and PEM fuel cells are functionally equivalent. Thus, the

Examiner argues that teachings with respect to batteries (as set forth in the Tripathy et al. publication) are applicable to PEM fuel cells and, thus, the invention claimed by Applicant involves nothing more than ordinary skill in the art. Applicant respectfully disagrees.

Applicant respectfully urges that *fuel cells and batteries are not functional equivalents as asserted by the Examiner*. MPEP § 2144.06 states:

“In order to rely on equivalence as a rationale supporting an obviousness rejection, the equivalency must be recognized in the prior art, and cannot be based on applicant’s disclosure or the mere fact that the components at issue are functional or mechanical equivalents (emphasis added).”

Thus, Applicant respectfully urge that *merely because batteries and PEM fuel cells both may have anodes, cathodes, and proton exchange membrane electrolytes does not make batteries and PEM fuel cells functional equivalents*. Applicant respectfully urges that a fuel cell, although having components and characteristics similar to those of a typical battery, differs in several respects, a fact known to those skilled in the art and expressed in the prior art (See pages 1-1 to 1-2 of Hirschenhofer, J.H. et al., Fuel Cell Handbook, Fourth Edition, U.S. Department of Energy, November 1998, copies of which are enclosed herewith). For one thing, it is well known to those skilled in the art that *the battery is an energy storage device*. The maximum energy available from a battery is determined by the amount of chemical reactant stored within the

battery itself. The battery will cease to produce electrical energy when the chemical reactants are consumed (i.e. when the battery is discharged). In a secondary battery, the reactants are regenerated by recharging, which involves putting energy into the battery from an external source. In direct contrast thereto, it is also well known to those skilled in the art that *a fuel cell is an energy conversion device* that theoretically has the capability of producing electrical energy for as long as the fuel and oxidant are supplied to the electrodes. In reality, degradation, primarily corrosion, or malfunction of components limits the practical operating life of fuel cells. Thus, the electrochemical environment as well as the operating conditions of a battery *are substantially different* from the electrochemical environment and operating conditions of a fuel cell. As a result, to the extent that batteries may use catalytic electrodes, longevity of the catalyst is not an issue because the life expectancy of batteries is very limited. In contrast thereto, the longevity of a catalyst in a continuously operating fuel cell having potentially unlimited life expectancy is a critical issue. In addition, in a fuel cell, the electrodes are used to convert a fuel, such as hydrogen or methanol, to electricity and, thus, must be able to perform this function. In contrast thereto, batteries do not convert fuels to electricity and, indeed, do not have the means for such conversion. Thus, the function of the electrodes of a battery are very different from the function of the electrodes of a fuel cell. Given these differences in

functionality between a battery and a fuel cell, Applicant respectfully urges that teachings relating to materials suitable for use in battery electrodes are not readily applicable to fuel cell electrodes and the materials suitable for use therein.

Applicant further respectfully urges that, if batteries and fuel cells are functional equivalents as suggested by the Examiner, they should be able to be used interchangeably. While it is true that fuel cells may be used as substitutes for batteries, it is clearly not the case that batteries can be substituted for fuel cells. For example, fuel cells convert fuels to electricity and, thus, due to their capability of continuous operation, may be employed for residential, commercial and industrial power generation, whereas batteries are not capable of converting fuels to electricity, are not capable of continuous operation due to the fact that they become discharged during operation and, thus, are not suitable for residential, commercial and industrial power generation. It follows that the problems solved by the invention claimed by Applicant including reducing fuel crossover from the anode to the cathode in a fuel cell and catalytic longevity are not issues needing to be addressed in batteries since fuel conversion is not a function of which batteries are capable. Accordingly, Applicant respectfully urges that, due to the functional differences between batteries and fuel cells, one skilled in the art would not be motivated to apply teachings relating to the electrodes of batteries to the electrodes of fuel cells. Accordingly, Applicant

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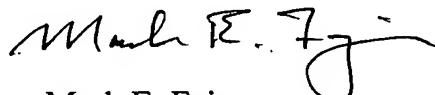
respectfully urges that the Srinivas publication and the Tripathy et al. publication, alone or in combination, do not render Applicant's claimed invention obvious in the manner required by 35 U.S.C. 103(a).

Conclusion

Applicant intends to be fully responsive to the outstanding Office Action. If the Examiner detects any issue which the Examiner believes Applicant has not addressed in this response, Applicant urges the Examiner to contact the undersigned.

Applicant sincerely believes that this patent application is now in condition for allowance and, thus, respectfully requests early allowance.

Respectfully submitted,



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1. TECHNOLOGY OVERVIEW

1.1 Fuel Cell Description

Fuel cells are electrochemical devices that convert the chemical energy of a reaction directly into electrical energy. The basic physical structure or building block of a fuel cell consists of an electrolyte layer in contact with a porous anode and cathode on either side. A schematic representation of a fuel cell with the reactant/product gases and the ion conduction flow directions through the cell is shown in Figure 1-1.

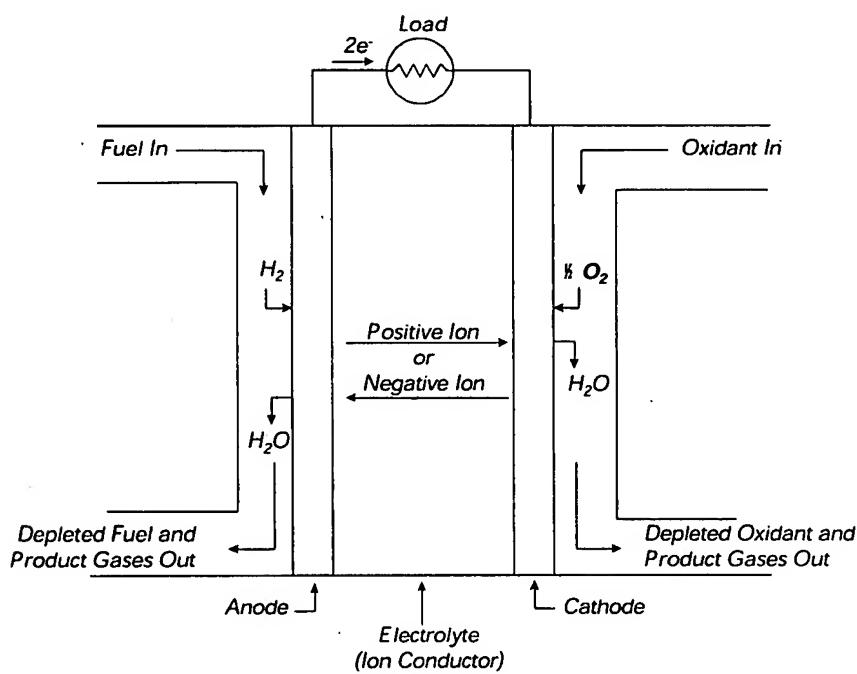


Figure 1-1 Schematic of an Individual Fuel Cell

In a typical fuel cell, gaseous fuels are fed continuously to the anode (negative electrode) compartment and an oxidant (i.e., oxygen from air) is fed continuously to the cathode (positive electrode) compartment; the electrochemical reactions take place at the electrodes to produce an electric current. A fuel cell, although having components and characteristics similar to those of a typical battery, differs in several respects. The battery is an energy storage device. The maximum

~~energy available~~ is determined by the amount of chemical reactant stored within the battery itself. The battery will cease to produce electrical energy when the chemical reactants are consumed (i.e., discharged). In a secondary battery, the reactants are regenerated by recharging, which involves putting energy into the battery from an external source. The fuel cell, on the other hand, is an energy conversion device that theoretically has the capability of producing electrical energy for as long as the fuel and oxidant are supplied to the electrodes. In reality, degradation, primarily corrosion, or malfunction of components limits the practical operating life of fuel cells.

Note that the ion species and its transport direction can differ, influencing the site of water production and removal, a system impact. The ion can be either a positive or a negative ion, meaning that the ion carries either a positive or negative charge (surplus or deficit of electrons). The fuel or oxidant gases flow past the surface of the anode or cathode opposite the electrolyte and generate electrical energy by the electrochemical oxidation of fuel, usually hydrogen, and the electrochemical reduction of the oxidant, usually oxygen. Appleby and Foulkes (1) have noted that in theory, any substance capable of chemical oxidation that can be supplied continuously (as a fluid) can be burned galvanically as the fuel at the anode of a fuel cell. Similarly, the oxidant can be any fluid that can be reduced at a sufficient rate. Gaseous hydrogen has become the fuel of choice for most applications, because of its high reactivity when suitable catalysts are used, its ability to be produced from hydrocarbons for terrestrial applications, and its high energy density when stored cryogenically for closed environment applications, such as in space. Similarly, the most common oxidant is gaseous oxygen, which is readily and economically available from air for terrestrial applications, and again easily stored in a closed environment. A three phase interface is established among the reactants, electrolyte, and catalyst in the region of the porous electrode. The nature of this interface plays a critical role in the electrochemical performance of a fuel cell, particularly in those fuel cells with liquid electrolytes. In such fuel cells, the reactant gases diffuse through a thin electrolyte film that wets portions of the porous electrode and react electrochemically on their respective electrode surface. If the porous electrode contains an excessive amount of electrolyte, the electrode may "flood" and restrict the transport of gaseous species in the electrolyte phase to the reaction sites. The consequence is a reduction in the electrochemical performance of the porous electrode. Thus, a delicate balance must be maintained among the electrode, electrolyte, and gaseous phases in the porous electrode structure. Much of the recent effort in the development of fuel cell technology has been devoted to reducing the thickness of cell components while refining and improving the electrode structure and the electrolyte phase, with the aim of obtaining a higher and more stable electrochemical performance while lowering cost.

The electrolyte not only transports dissolved reactants to the electrode, but also conducts ionic charge between the electrodes and thereby completes the cell electric circuit, as illustrated in Figure 1-1. It also provides a physical barrier to prevent the fuel and oxidant gas streams from directly mixing.

The functions of porous electrodes in fuel cells are: 1) to provide a *surface* site where gas/liquid ionization or de-ionization reactions can take place, 2) to *conduct* ions away from or into the three-phase interface once they are formed (so an electrode must be made of materials that have good electrical conductance), and 3) to provide a physical *barrier* that separates the bulk gas phase and the electrolyte. A corollary of Item 1 is that, in order to increase the rates of reactions, the electrode material should be catalytic as well as conductive, porous rather than solid. The